DEVELOPMENT OF CORRELATION METHODOLOGY USING OPTIMIZATION TECHNIQUE

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ABSTRACT

Recently, the applications of optimization technique for occupant simulation are increasing to achieve a good correlated model, simulation reliability with actual test condition and design improvement. However, when the simulation model becomes complicated, the number of unknown parameters increases. Currently, point (one dimension) parsing has been used in optimization technique. Therefore, it takes longer time to parse all design parameters and to control the input parameters after parsing design parameters. Also, a longer time is required to run all input parameters.

To overcome this problem and achieve a good correlated model with test, this study introduces the new developed process, curve parsing method (two dimension parsing) and applications for correlation methodology with test and simulation using optimization technique. Particularly, the component and system level of occupant simulation are applied to the program developed with Engineous. Thus, simple parsing with the design parameters can be achieved for the optimization technique application.

From the result, the convergence accuracy of new approach was better than the old approach with specific optimization techniques. And the simulation run numbers and time had dramatically reduced compared to the ones in the previous approach.

INTRODUCTION

Traditionally, the trial and error method for correlation of occupant simulation has been used. The correlation quality and reliability of simulation depended on engineer’s experience, comparison of results and deviation of acceleration shape. Currently, the correlation methodology that can numerically express the correlation level has been developed by some company. Deren Ma, Jennifer Matlack, et al.,[1] presents the paper that the correlation quality of overall kinematics and dynamic response is scored and color-cored from weak, marginal, adequate, good to excellent. And Jack Van Hoof, et al.,[2] introduced a commercial software package “ADVISOR” which contains a model quality-rating module with its own measurement criteria. In this manner, the correlation methodology is very critical and most sensitive in simulation area.

Recently, the usage of optimization technique at occupant simulation are increasing to obtain good correlation with actual test [(1)~(6)]. Especially, Yan Fu, Eung Lee, et al [3] attempted to solve the problem systematically by using a genetic algorithm which is a valuable optimization tool to obtain a high quality simulation model.

Also the multi-body dynamic model has many uncertain parameters. For the example, in case of ellipsoid modeling, the geometry of actual shape can not be exactly represented and can not be modeled with exact material damping and moment of inertia, joint stiffness, etc. Also, it requires tremendous time to correlate with actual test, although the model has exact input shape, moment of inertia and so on. However, the optimization technique can be easily applied at multi-body dynamic model because it does not take a long time to run.

In case of frontal MADYMO simulation model, it requires more than 25 force-displacement curve data including loading and unloading curves. And it takes a long time (about 2months) to obtain those curve data from proto component tests. Also, even after gathering all F-D curve data, we usually spend a long time to correlate with component test results. Nevertheless, many assumptions for correlation are required to give a reliable occupant simulation before conducting the component test. Also, assumptions are required when there are only sled and barrier test results without component test results.

Currently, the optimization program is deficiency since it parses the input parameters using 1demesional point. For example, a lot of time is spent to parse the input parameters when a certain curve to object function needs parsing.

To overcome this problem and achieve the good correlated model with test, this study introduces the new developed process, curve parsing method (two dimensional parsing) and applications for correlation methodology with test and simulation using optimization technique.

CURRENT SIMULATION METHOD

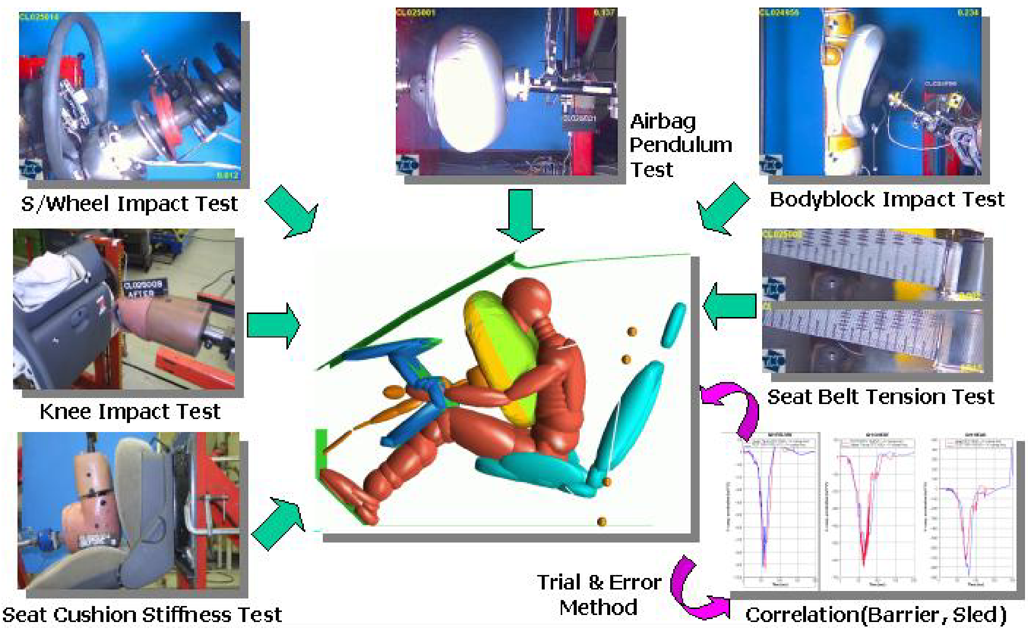


Figure 1. Current process of occupant simulation

Currently, MADYMO (MAthematical Dynamic MOdeling) program prevails in the occupant simulation, but we need a lot of component test results (F-D curve) to build the frontal occupant simulation. Previously, the trial and error method to correlate with actual test and tune the F-D curve and uncertain parameter has been used in occupant simulation. (see Figure 1.)

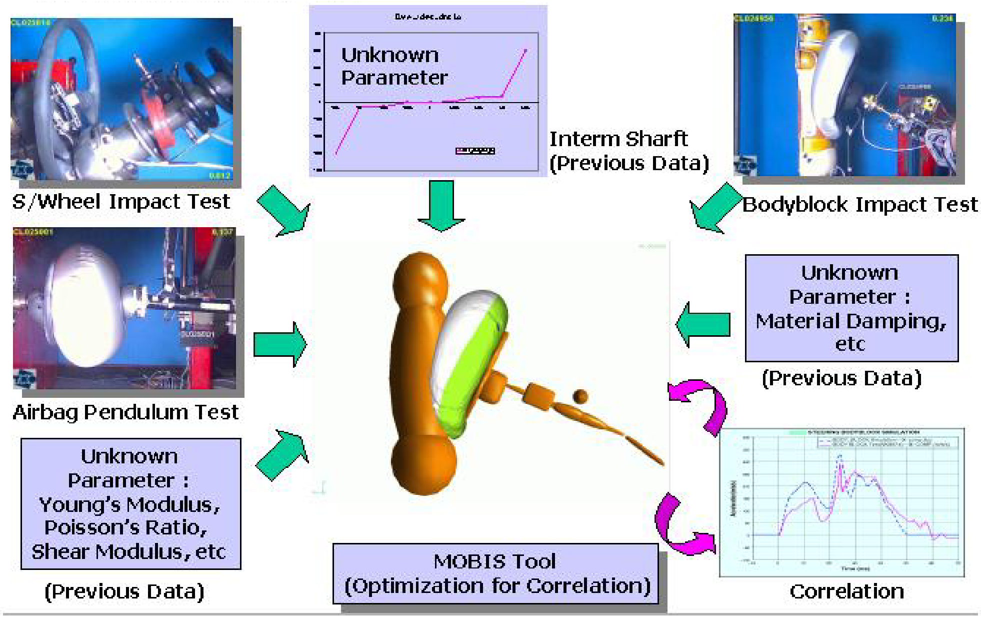


Figure 2. Example of correlation optimization

Therefore, a centralized correlation optimization can help to solve the problem using commercial software, i-SIGHT.

Also, the centralized correlation optimization program was developed to match test and simulated curves automatically when using the old data (previous vehicle data) without the new vehicle component test results or the unknown parameter in components model.(see Figure 2.)

CURRENT OPTIMIZATION PROBLEMS

Currently, the optimization program supports just 1 dimensional point value for objective and input parameter parsing. Therefore, a user confronts difficulty to input the curve for objective and input parameters. And the automation job is needed when comparing test and simulation curves in every simulation. Also, it require a long time to parse the objective function (test and simulation), specially when input parameter have many curves. And even after finishing parsing of all curves to object, the total run number is increased and it requires a long time to run the simulation.

PROGRAM DEVELOPMENT

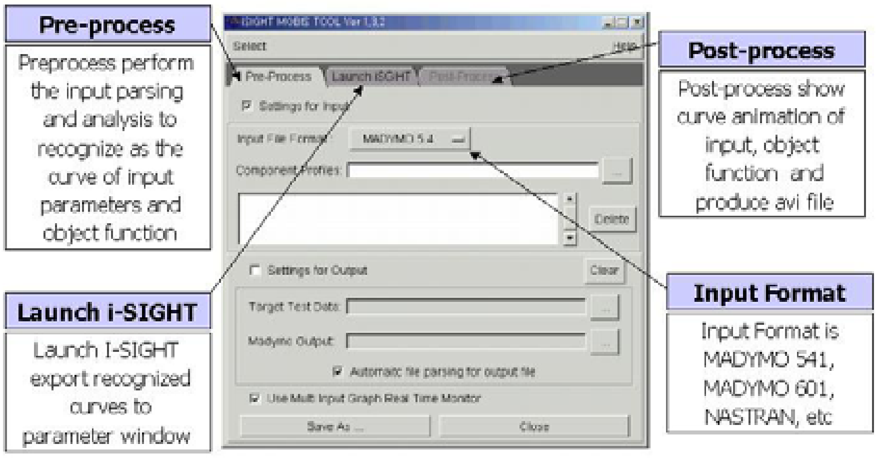


Figure 3. Pre-processor description

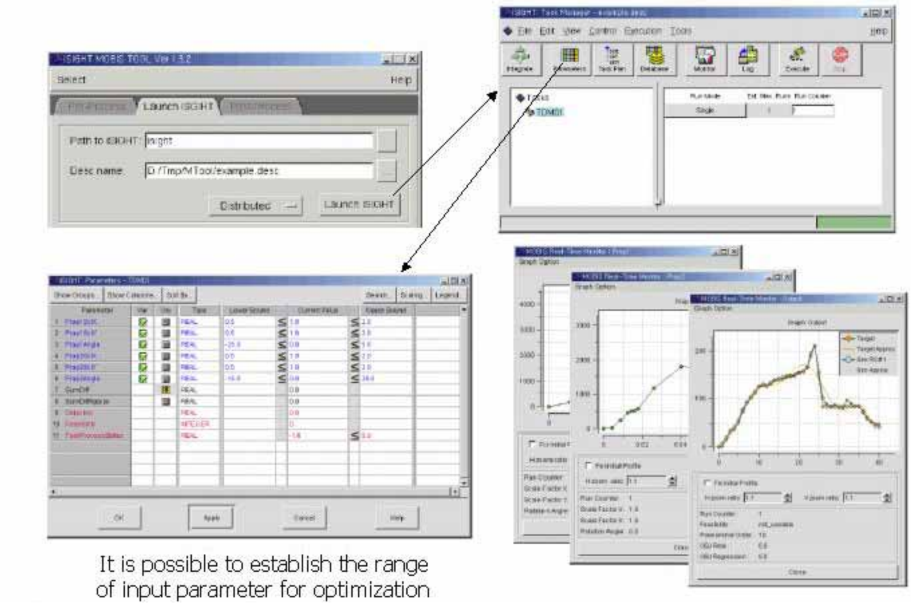


Figure 4. Launch I-SIGHT description

The program consists of three parts : pre-processor, launching i-SIGHT and post processing. The pre-processor includes a process that parses input parameters for curves through the curve fitting or exponential to parse physical means of the acceleration curve shape. Then, this can be compared with the simulation and test acceleration result. (see Figure 3.)

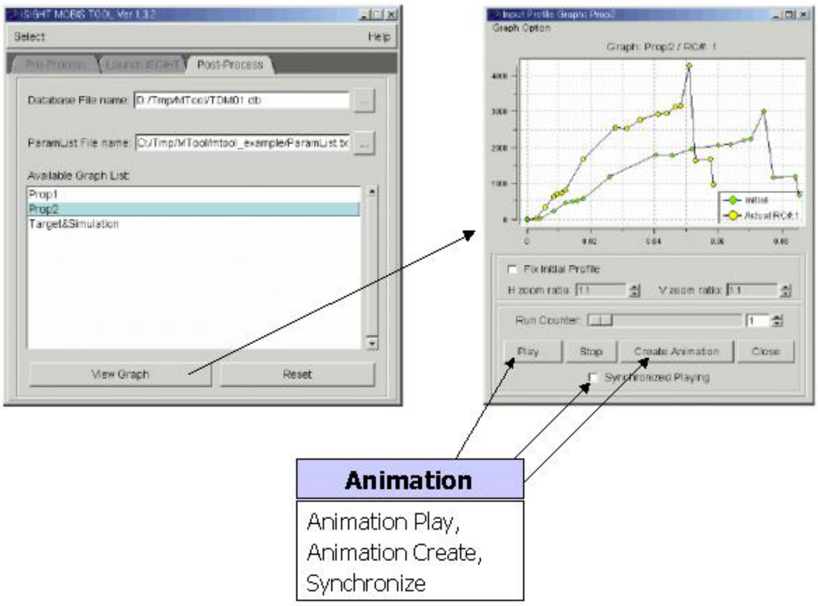


Figure 5. Post Processor description

The launching of i-SIGHT brings the parsed input parameter or objective function (curves) from the pre-processor into i-SIGHT program. (see Figure 4.) Then, the post-processor shows the simulated results and optimized results, and the convergence process of simulation can be animated and exported to the animation files. (see Figure 5.)

PROGRAM EVALUATION

To evaluate the developed program, the deflection example of a simply supported beam (cantilever beam) solved by NASTRAN has been applied. As a result (see Table 1.), the number of parameters reduced considerably than the ones in old method. The accuracy of convergence is higher than the one in old method. And only 20%~34% of simulation run time of the old method was taken.

Method	Parsing Method	Number of Parameter	Accuracy of Convergence	Run Time(Run Number)
Old Method	1Dimension (Value,Point)	A lot	-LHC+MMFD : 59.7% -SA+HJ : 92.8%	100%
MOBIS Tool	2Dimension (Curve)	Few	-LHC+MMFD : 99.1% -SA+HJ : 89.6%	20%~34%

LHC : Latin Hyper Cube
MMFD : Modified Method of Feasible Directions
SA : Simulated Annealing
HJ : Hooks-Jevees Pattern Search

Table 1. Evaluation results of MOBIS tool

PROGRAM APPLICATIONS

Droptower Test and Simulation

The droptower example with objective function curve and input parameter of point value is shown in Figure 6.

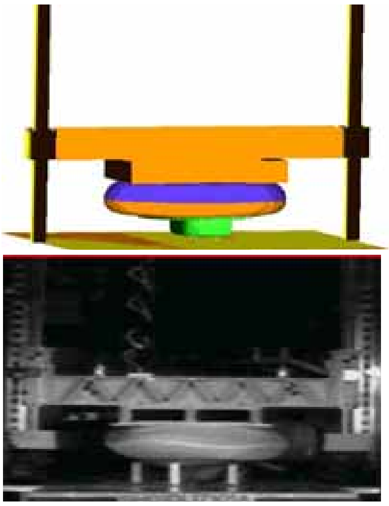


Figure 6. Droptower test and simulation

Also, the acceleration pulse before correlation optimization is shown in Figure 7 and the comparison results of acceleration after correlation optimization is shown in Figure 8.

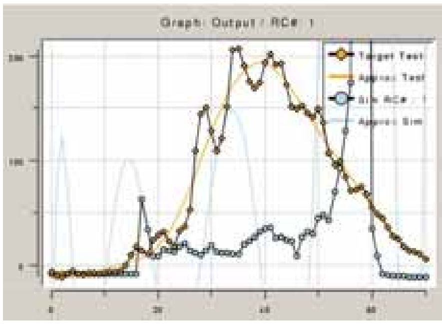


Figure 7. Before the correlation optimization

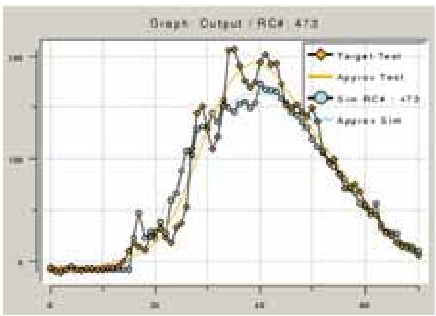


Figure 8. After the correlation optimization

Knee Impact Test and Simulation

The knee impact example with objective function and input parameter curves is shown in Figure 7.

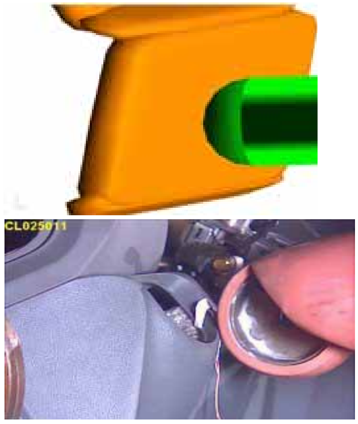


Figure 9. Knee impact test and simulation

The tolerance can be found even though the F-D curve has been extracted from component test results since mostly the kneebolster surface is a plane and it requires modification of F-D curve obtained from component test result using the FE model for kneebolster. Therefore, correlation optimization or trial and error method are needed in order to compare with component result.

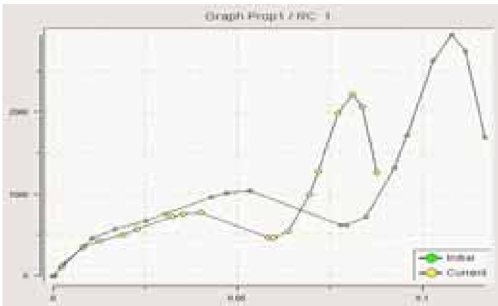


Figure10. Before the correlation optimization (1)

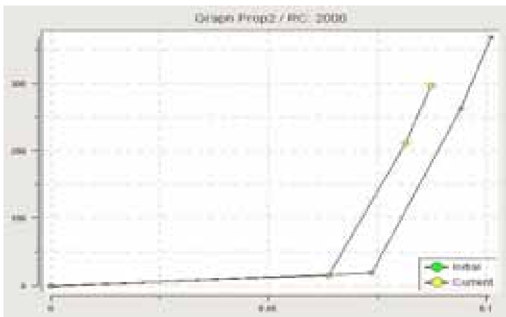


Figure11. Before the correlation optimization (2)

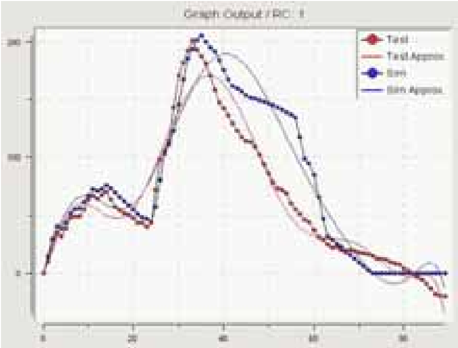


Figure12. Acceleration pulse before correlation optimization

Figure 10 shows the kneebolster loading curve before correlation optimization, Figure 11 shows the kneebolster unloading curve before correlation optimization, and Figure12. show the comparison of results of knee impact test and simulation acceleration before correlation optimization.

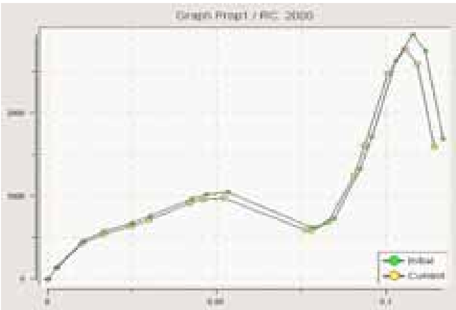


Figure 13. Input parameter of K/Bolster-loading curve after correlation optimization

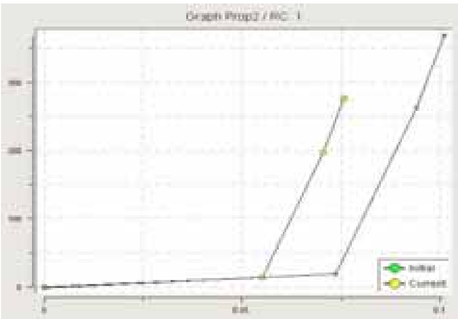


Figure 14. Input parameter of K/Bolster-unloading curve after correlation optimization

Figure 13 and 14 show the kneebolster loading and unloading curve after correlation optimization, and Figure 14 shows the comparison of results of knee impact acceleration curve between simulation and test.

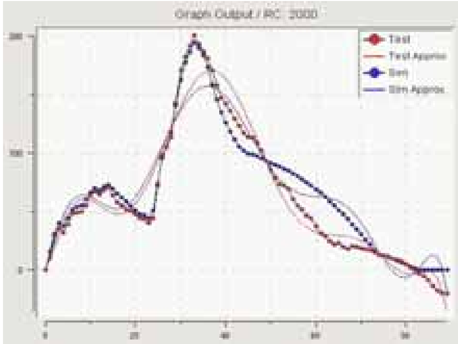


Figure 15. Acceleration pulse after correlation optimization

<u>Steering Wheel Impact Test and Simulation</u>

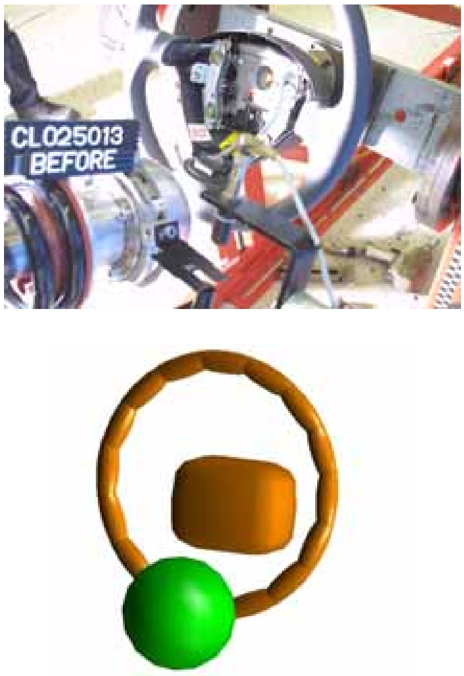


Figure 16. Steering wheel stiffness test setup and simulation model

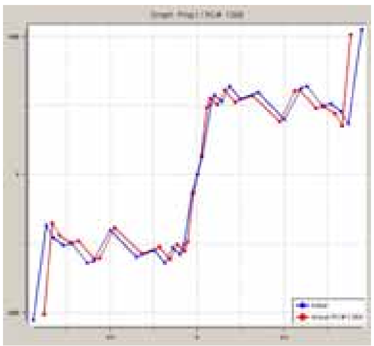
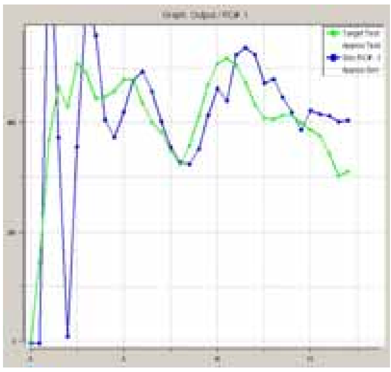
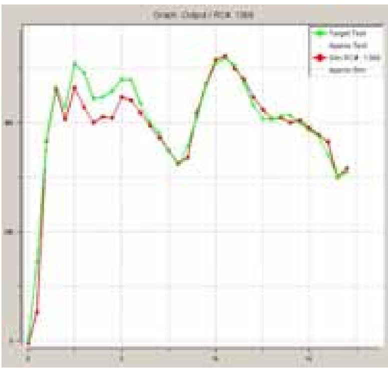


Figure 17. Rim joint stiffness curves with correlated model and original model



(a) Head form acceleration of initial model



(b) Head form acceleration of correlated model

Figure 18. Correlation of the head form acceleration in simulation model with the component test

Bodyblock Impact Test and Simulation

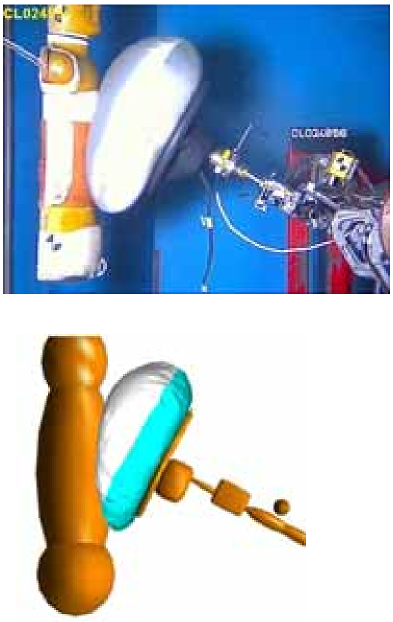
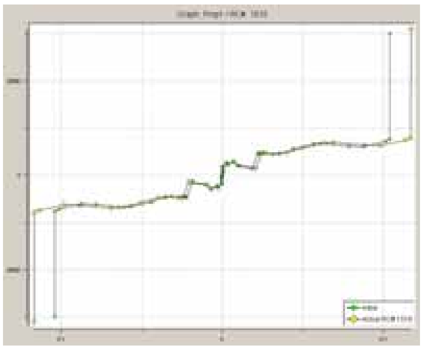
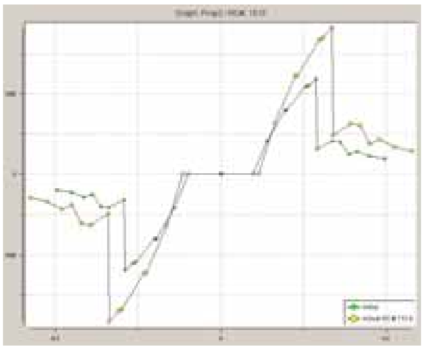


Figure 19. Bodyblock test and simulation

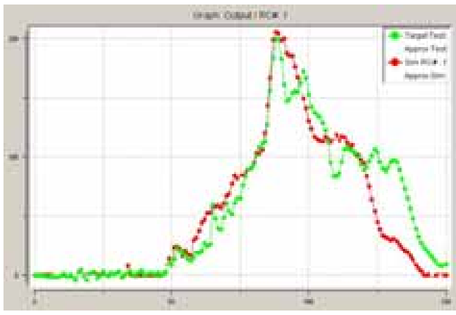


(a) Steering column axial stiffness

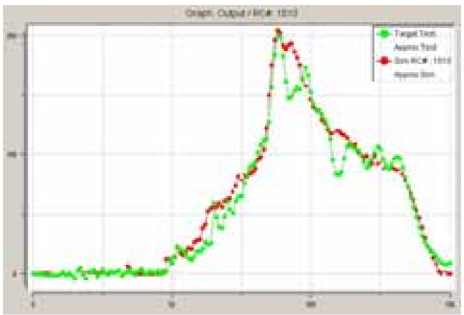


(b) Steering column tangential stiffness

Figure 20. Comparison of initial and optimal F-D curves of joints



(a) Body block acceleration of the initial model



(b) Body block acceleration of the correlated model

Figure 21. Comparison of bodyblock acceleration in test and simulation

CONCLUSION

In order to overcome the old correlation optimization with many problems (i.e. parsing difficulty, numerous input parameters, long run time) and to achieve good correlated model with test, this study introduced the new developed process, curve parsing method (two dimensional parsing method) and applications for correlation methodology with test and simulation using optimization technique. And the conclusion remarks are as follows.

1. It was possible to reduce the run time and number of run because the curve was recognized as one parameter.
2. It was possible to predict the unknown parameters (Specific Curve, Damping, Friction, etc) using optimization technique.
3. It was possible to construct the validated simulation model and simulation procedure.
4. The optimization technique used in this study was very suitable for the correlation of the occupant simulation model that has 2-dimensional test input data (F-D curve).

   It will be a powerful tool for correlation problem between test and simulation using optimization technique.

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